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AUTHOR Richek, Margaret Ann
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ABSTRACT

Test questions were phrased according to different sentence structures in a study of the complexity level of items for 220 third-grade children. Both the sensitivity of wh-questions (who, what, where, etc.) as a dependent variable and differences between wh-questions eliciting subject and predicate nouns were investigated. Effects of paraphrase alternations (nouns vs. pronouns) and different levels of complexity in sentences were studied in reference to their effects on wh-questions. Results indicated questions eliciting a subject node were easier than questions eliciting predicate nodes. No significant interactions were observed between questions and paraphrase or complexity variables. Differences in question difficulty might have been due to factors in the question itself or in the sentence. Permutation of sentence elements in questions eliciting predicate nouns was also discussed. The salience of the first noun (the subject) in a sentence was suggested as a possible facilitating effect; evidence supported this theory for the first noun in an independent clause. Further, results implied that two independent clauses are not closely psychologically bound. Overall, questions were shown to be a sensitive measure of comprehension difficulty. (Author/MV)

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THE EFFECTS OF PARAPHRASE ALTERNATION AND SENTENCE COMPLEXITY ON WH-QUESTIONS

Margaret Ann Richek
University of Illinois
at Chicago Circle

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Bormuth (1970) put forth a critique of existing item writing techniques. He concluded that existing practices showed four basic deficiencies: items were not independently reproducible; claims concerning the category of a given item could not be verified; sampling techniques for testing instruction could not be defined; and the relationship between instruction and test item could not be defined. Responding to these inadequacies, Bormuth constucted criteria for constructing achievement test items. Below are the criteria for acceptable items:

> An item can be said to be relevant to instruction only if the item and its correct response can be derived from a specified segment of the instruction by using a set of operations which can be both generalized across instructional programs and described in objective terms. . . a given set of operations should be capable of being systematically applied to an instructional program in such a way that all the items of the type derivable by those operations will be produced. (pp. 34-35)

Bormuth then illustrated techniques that could be used on samples of sentence-length prose.

The present study uses the logical format described by Bormuth to define a population of test items and to derive and test these items. In addition, the psychological properties of test items are investigated. First, the difficulty of two item types are compared. Second, the feasibility of using rote questions is investigated.

The necessity for testing the comprehension of sentences arises frequently in elementary instruction. In order to determine whether a child has comprehended a sentence, it is necessry to determine what elements constitute the sentential relationships of interest. Thus, the experimenter must define an appropriate

population of items. The most frequently used item types elicit identification of the sentential subject. However, other important information exists within a sentence. In this experiment, two types of items were tested, those eliciting the subject and those eliciting a nonsubject node. Because of the substantive thrust of the experiment (the identification of anaphoric antecedents) these two types of items were considered relevant by the experimenter; in addition, including two item types yielded some comparison of the difficulty of each. An example of the two item types formed over one paradigmatic sentence follows:[1]

(1) Bob met Mrs. Smith on the cormer and <u>he</u> helped <u>her</u> to cross the street
   (a) Subject node tested: Who helped her to cross the street?
   (b) Nonsubject node tested: Who did he help to cross the street?

In addition to testing the differences between question types, this study may be regarded as an assessment of the use of questions as a methodological issue. Although a considerable body of work now exists on listening and reading comprehension, the best method of measuring comprehension remains an open question. Although the ability to answer questions is generally considered a true measure of sentence comprehension, the unreliability and difficulty of question construction has caused many researchers to abandon questions for more dependable tools. A variety of dependent variables have been used, including sentence repetition, close procedure, rapid visual presentation, and probe latency. These tools, although reliable, do not reflect the processes by which children demonstrate comprehension in school situations. In fact, researchers have shown different processing techniques between, for example, the probe latency technique and questioning (Gamlin, 1972).

The use of Bormuth's algorithims enables the experimenter to use a method which is both reliable and parallels the school comprehension assessment. The present study provides an assessment of whether this method is a sensitive measure of comprehension difficulty.

The experiment in which questions were incorporated had two basic aims. The first of these was to assess the effects of paraphrase alternations in facilitating comprehension of anaphoric structures. To investigate this problem, a snytactic structure commonly found in reading textbooks was used. This structure is a conjoined sentence with repeated anaphoric references. The study compared the effects of using two paraphrase alternates, nouns and pronouns, to represent the anaphoric structure in the second independent clause of the conjoined sentence. Examples (1) and (2) illustrate this

(1) Bob met Mrs. Smith on the corner and Bob helped Mrs. Smith to cross the street.
(2) Bob met Mrs. Smith on the corner and he helped her to cross the street.

The reader will note that sentences (1) and (2) differ in form, but not in meaning. If paraphrase alternations proved to differ in difficulty, editors would have a useful tool enabling them to express the same content in a more comprehensible form. In the study, it was hypothesized that the reduction of a noun to a pronoun would decrease the reader's comprehension because of the concommitant deletion of information.

A second aim of this study was to compare the comprehension of the anaphoric form in relation to various levels of sentence complexity. It is obvious that a large number of sentences, varying considerably in complexity would conform to the basic sentence type used in this study. Such sentences may vary from the relatively

simple examples given above to highly complex formations. In order to adequately assess children's abilities to understand the anaphoric process in the sentence type studied, it seemed necessary to examine the effects of sentence complexity on comprehension by testing at least some of the many levels of complexity that were present in basal readers. Thus, variations in the complexity of the stimulus sentence were incorporated into the experimental framework through the use of four variables: length, kernels, parallelism, and node questions.

Kernels were operationalized as the number of intervening sentence kernels separating the antecedent and anaphoric structure. Length was defined as the number of words between these two structures. Parallelism was defined as parallel or switched construction between the subject and nonsubject node of the first and second independent clauses in any compound sentence. This is illustrated with sentences (3) and (4).

(3) Parallel construction: John saw Mary and said hello to her.

(4) Switched construction: John saw Mary and she said hello to him.

The node questioned variable was defined as questions formed over either the subject or nonsubject anaphoric structure in the second sentence.

Method

Subjects

The subjects were two-hundred twenty third-grade children in a suburban public school district. Reading achievement scores indicated that the children were reading at national norms, when considered as a district. The children were tested during the month of June. Subjects experiencing difficulty in word recognition were eliminated by the use of a word recognition criterion test. Each of the subjects received half of the sentences.

Construction of Materials

Levels of Complexity Variables. Each of the four complexity variables was assigned two levels. The number of embedded kernels separating antecedent and anaphoric structure were none for the "few" level, and two for the "many" level. Kernels included marked and unmarked relative clauses, nominalizations, subordinated sentences, and complement structures, but not adjectives. For the length variable, the "short" level was defined as the separation of the antecedent and the anaphoric structure by ten to twelve words; in the "long" level, the separation was sixteen to eighteen words. Sentences were adapted to either a parallel or switched form. For the node questioned variable, either the subject or the nonsubject anaphoric structure of the second independent clause of the test sentence was tested.

Adapting Sentences. Sentences from third grade basal readers supplied the basic sentence frame for each test sentence. Each sentence from the reader was randomly assigned a combination of the four complexity variables. Often, the original sentence had to be adapted to the specifications of these variables.

Each sentence contained main clause conjunction and two anaphora pairs. The antecedent of each pair was before the conjunction, and the anaphoric structure after the conjunction. To avoid ambiguity, the two antecedents carried different case of gender markers.

The primary interest of the experimenter was to determine the efficacy of the paraphrase alternation. To compare these differences most directly, the same "sentence frame" was used to asses the differences between two sentences that had been assigned the same combinations of complexity variables, but which differed in the paraphrase alternate (noun or pronoun). The two sentences within each frame were controlled for number and types of clauses. Specific words within the sentences varied. Examples of two such sentences, one a noun alternate and one a pronoun alternate, is given below:

(5) Bob had a box for tin soldiers and his other toys and Bob liked the box because it was big.

(6) Marsha had a box for bracelets and other kinds of things and she loved it because it played music.

Questions asking for the identity of one of the two antecedents in the sentence were derived systematically following Bormuth (1970). All references to anaphora in the question were put into pronominal form. Children were asked to respond to the question by writing a one word answer identifying the appropriate antecedent.

The test sentences were embedded in a three sentence context. The position of the sentence was randomly assigned. In one of the three surrounding sentences of each paragraph, an additional referent was included that might serve as a distractor. The

paragraphs used were compiled into two booklets, split on the length variable. One containing "long" test sentences, and one containing "short" test sentences. The order of the pages was rotated to avoid systematic order effects.[2]

Experimental Design. This was a 2 x 2 x 2 x 2 x 2 factorial design, with two levels each of paraphrase, length, kernels, parallelism, and node questioned. This would have produced thirty-two test items. However, since sentences were conceptualized as a random variable, two sentences were included to represent each of the thirty-two distinct combinations of the five variables. This resulted in a total of 2^6 or sixty-four items. Sentence frame was nested within length, kernels, parallelism, and node questioned, but crossed the paraphrase variable. The design is summarized in Table One.

Testing Procedures. The experimenter administered the test to one classroom of children at a time. First, children took the word recognition test, and then either the "long" or the "short" sentences. Two practice items familiarized the children with the testing procedure. No time limit was imposed, but children were encouraged to finish. Three incomplete tests were eliminated from the analysis.

Scoring Procedures. Correct answers identified the antecedent in a noun form. Neither pronoun answers nor global categories (e.g., man where John is correct) were counted as correct.

Results

Treatment of Data

A univariate analysis of variance (BMD, 08V, Dixon, 1971) was

performed on both sets of data. Due to the fact that the experimental design was incomplete, it was necessary to derive quasi-F ratios for some variables, as described by Winer (1962). Both subjects and sentence frame were treated as random variables. Coleman (1964) and Clark (1973) have highlighted the importance of conceptualizing experimental sentences as drawn from an infinite population of sentences.

Findings

Results of the analyses are shown in Table Two. Table Three presents the percent correct on selected variables. Results showed that paraphrase alternates differed significantly, with noun alternates easier to comprehend than pronoun alternates. Three of the four complexity variables, kernels, length, and parallelism did not show significant main effects. However, these variables formed a significant three-way interaction. The remaining complexity variable, node questioned, showed a significant main effect, with nonsubject nodes being more difficult to produce. Sentence frames differed significantly in difficulty. In addition, sentence frame interacted with paraphrase alternation. There were significant differences in subject's performance. Subjects responded differently to paraphrase alternation and to sentence frames as indicated by the two-way interactions between subjects and these variables.

Discussion

The results of this study demonstrate the efficacy of the paraphrase alternation for manipulating the difficulty of reading materials. Although three complexity variables did not show

direct effects on comprehension, results indicated that complexity did affect comprehension in very specific ways. This was first suggested by the significant kernel-length-parallelism interaction. Second, the significance of the sentence frame variable, which represents simultaneous control of all complexity variables, indicated that when very fine control was used in sentence construction, the complexity of the frame affected difficulty.

The significance of the node questioned variable demonstrates differences in the difficulty of subject and nonsubject nodes. Differences in the difficulty of eliciting different nodes has also been demonstrated by Weiss (1974) who found relative clauses particularly hard to elicit. Thus, the difficulty of the sentence seems to be a function of the information tested in that sentence. The effect of the node questioned in this experiment is quite stable, as shown by its lack of interaction with other variables.

Although the difficulty of nonsubject nodes has been demonstrated, the causes of this difficulty cannot be determined. The question itself could be causing the difficulty. Bormuth (1970) describes the procedures for constructing rote questions from both subject and predicate nouns. For subject nouns, the process involves five steps, culminating in a pro element replacing the subject of the sentence. For predicate nouns, the process involves seven steps, the insertion of a visible auxilary and a shift in the tense marker (if an auxilary is not already present), the replacement of the noun tested by a pro element, and the shift of both the pro element and the auxilary to the front of the sentence. The difference in the complexity of question derivation is reflected by subsequent differences between the original

sentence and the items testing it. For demonstration purposes, Sentence (1) and its two questions are repeated below:

(1) Bob met Mrs. Smith on the corner and he$_{1}$ helped$_{2}$ her$_{3}$ to cross the street$_{4}$

(a) Subject node tested: Who$_{1}$ helped$_{2}$ her$_{3}$ to cross the street$_{4}$

(b) Nonsubject node tested: Who$_{3}$ did$_{X}$ he$_{1}$ help$_{2}$ to cross the street$_{4}$

The subject node question does not change the position of the elements of the original sentence. Thus, if the reader had formed a "set effect" by, for example, repeating the sentence to himself, the recall of the subject noun would be facilitated. On the other hand, the nonsubject node question involves considerable permutation, the insertion of a new element, and a change of a tense marker. Thus, set effects would not be expected to facilitate the production of the predicate noun. This would eliminate one road to "comprehension" and thus, be expected to lower the number of correct answers.

The difference observed between subject and nonsubject nodes may also be due to the properties of the sentence. In this experiment, only active sentences were used, ensuring that the subject node was the first word in the second independent clause. Several researchers have found that the first noun in a sentence is the semantic focus of that sentence. Katz (1972) summarizes this theory:

> It has long been recognized that the noun phrase that occupies this (the first) position has a special import, the nature of which can be brought out by

> considering the case where the sentence starts the discourse. In this context, the left-most noun phrase in the surface structure of the sentence normally conveys the topic of the discourse, unless some special device is used to deviate from this rule for some clear stylistic purposes.

Using active and passive sentences, several experimenters have found that the first noun in a sentence, whether or not it is the deep structure noun, receives special attention. Turner and Rommetviet (1968) found that picture clues used to help subjects recall sentences tended to make them "recall" sentences in which the picture clue was recalled as the first noun. Thus, a passive sentence might be recalled as active if the deep structure subject was used as a clue. Segal and Martin (1965) found that the first noun in a sentence was rated as the most important element, whether the sentence was presented in active or passive form. Prentice (1966) found that increasing the salience of the first noun in either an active or passive sentence increased the ease of learning. These results implies that differences between the subject and nonsubject node may have been due to the salience of the subject as the first noun.

However, this tempting theory cannot quite be accepted at face value. For half of the sentences in the study were based on a switched form where subject and nonsubject referents switched part of speech functions, and therefore positions, in the first and second independent clauses of the test sentences (see sentences (3) and (4) for illustrations). Thus, if the first noun <u>in the sentence</u> were considered to be the psychological focus, an interaction between the node questioned variable and the parallelism variable would be expected. As no such interaction materialized, it appears that if a first noun is more salient, it is the first

noun of the independent clause (in this case, the second independent clause of the sentence).

The psychological integrity of the sentence comes into question. How well integrated must a string of words be just because they are bound by a capital letter and a period? Perhaps the question, since it only contained elements from the second independent clause, served to separate the two component clauses in the reader's mind. On the other hand, the relationships between these clauses may not be inherently closely bound. The change in deep structure subject in the switched sentences may have caused deterioration of sentential relationships.

One experimenter (Legsold, 1972a) has investigated relationships within sentences in a slightly different manner. He also used sentences containing two independent clauses and anaphoric references, some where the referents of the second independent clauses were given as nouns, and some where they were given as pronouns. Lesgold found that a probe in the second clause made adults recall the words in both clauses with equal probability if pronouns were used in the second clause. However, if nouns were used, adults were less likely to recall the first clause. Thus, he suggested that pronouns tended to unify sentences. However, replicating this experiment with eight to ten year-old children, Lesgold (1972b) found that sentences containing pronouns did not have the same facilitating effects, thus implying that children perceive sentences as less unified. This may explain the lack of interference caused by the first noun in the switched sentence. Future research is needed to sort out whether question or sentence effects are responsible for differences in difficulty that have

been observed.

Finally, the results of this experiment can be viewed as a validation of the use of questions as a dependent variable. Researchers have, in the past, relied on numerous response variables to measure comprehension. In this regard, it is useful to consider the criteria that could be used for judging the "goodness" of such a variable.

One can imagine that there is an abstract quality called "comprehension of sentences" for which we seek an accurate, sensitive, or at least unbiased measure. The concept of such latent traits is not new, but is common to education in such forms as "intelligence". We cannot assess such latent qualities directly without a more sophisticated form of neurosurgery than is currently existing. The researcher, limited in resources, personal knowledge of his subjects, and unwilling to rely on intuition (indeed, objectivity is the very essence of his trade) is at a particular disadvantage in locating a dependent variable in which he can place some confidence.

There seem to be two methods available to the researcher for validating such a variable. The first is to refer to a widely accepted standard, if such a standard exists. Thus, IQ tests were originally validated by their prediction of school success, which was hypothesized, on common sense grounds to require some intelligence. Does such a standard exist with regard to "comprehension of sentences"? Perhaps the most commonly accepted standard is the reflection of language comprehension processes in a nonlanguage mode, particularly the ability to choose a picture which reflects certain critical features of a sentence. If this is, indeed, a commonly accepted criterion, one may judge different types of dependent

variables to be "good" to the extent to which they yeild results which agree with results from the picture criterion. Bortnick (1974) has begun a validation process using picture comprehension as a criterion variable.

A second manner in which the researcher can validate his response variable is by using a well known theory as a standard. If the results obtained using the dependent variable uphold the results predicted by theory, the variable is giving an accurate estimate of the process being investigated. The present experiment may be considered to validate the use of questions in this manner. A theory predicting that the deletion of information will hamper sentence comprehension has been asserted by many, but perhaps most succintly by Fodor amd Garrett (1967). At least three experiments conducted independently of the use of questions have validated this theory (Fodor and Garrett, 1967; Coleman, 1963; Coleman and Blumenfeld, 1964). In the present experiment, results supporting this theory are obtained using the question as the rdsponse variable. This provides a confirmation of the fact that questions do not obscure the comprehension process, that they give the researcher a sensitive measure of an underlying quality called "sentence comprehension".

However, a question arises as to whether the present experiment provides conclusive or merely suggestive evidence on the use of questions. This can be more fully explained by a consideration of a distinction, common to the physical sciences, between a <u>theory</u> and a <u>hypothesis</u>. A theory gains such status by a combination of a thoroughly reasoned logical process and by considerable experimental validation. In this regard, witness Einstein's "theory" of relativity. A theory may ultimately be changed, but, for the moment, it explains a considerable body of evidence, and is considered a stable basis for

experimentation. A response variable may be easily validated using a theory for, it has been shown, that results predicted by a theory will, in fact, materialize using other response variables.

A hypothesis may be distinguished from a theory by the lesser degree of confidence that may be placed in it. This is due to less experimental verification or, perhaps, less lucid logical explication. It is difficult to use a hypothesis to verify a response variable, since the results due to the effects of the hypothesis are themselves in doubt. If a hypothesis is used in this fashion, the inferences that can be drawn about the dependent variable are limited to implications rather than conclusions.

This reasoning implies that the extent to which questions can be validated using the results of the present experiment depends on the extent to which the prediction that deletion of information hampers comprehension is a theory or a hypothesis. Sadly, in the sciences of education and psychology, true theories are hard to come by. Thus, while the deletion of information has received a number of validations, there is some evidence (for example, Pearson, 1969) that deletion of information does not always hamper comprehension. In addition, other experimenters (for example, Weiss, 1974) find that the effects of sentential manipulations on comprehension are highly specific, thereby complicating the process of theory explication. Thus, the theory of deletion of information must still be considered a hypothesis (albeit a strong one) and the results of the present experiment have merely suggested that questions give an accurate and sensitive measure of underlying sentence comprehension.

FOOTNOTES

1. This sentence illustrates the pronoun paraphrase alternate.

2. Subjects are confounded with length. Two separate tests were administered. Each subject received either the short or long sentences.

TABLE 1

DESIGN OF THE NOUN-PRONOUN ANALYSIS

			Many Kernels		Few Kernels	
			Noun Paraphrase	Pronoun Paraphrase	Noun Paraphrase	Pronoun Paraphrase
Long Length	Switched Construction	Subject Location	F_1 F_2	F_1 F_2	F_5 F_6	F_5 F_6
		Non-Subject Location	F_3 F_4	F_3 F_4	F_7 F_8	F_7 F_8
	Parallel Construction	Subject Location	F_9 F_{10}	F_9 F_{10}	F_{11} F_{12}	F_{11} F_{12}
		Non-Subject Location	F_{13} F_{14}	F_{13} F_{14}	F_{15} F_{16}	F_{15} F_{16}
Short Length	Switched Construction	Subject Location	F_{17} F_{18}	F_{17} F_{18}	F_{19} F_{20}	F_{19} F_{20}
		Non-Subject Location	F_{21} F_{22}	F_{21} F_{22}	F_{23} F_{24}	F_{23} F_{24}
	Parallel Construction	Subject Location	F_{25} F_{26}	F_{25} F_{26}	F_{27} F_{28}	F_{27} F_{28}
		Non-Subject Location	F_{29} F_{30}	F_{29} F_{30}	F_{31} F_{32}	F_{31} F_{32}

Note.--Each sub script in Table refers to a unique sentence frame; "F" indicates sentence frame.

TABLE 2

RESULTS OF STATISTICAL ANALYSES[a]

Variable	F	df	p less than
Paraphrase (A)	15.1	1,15	.05
Kernel (K)	1.3	1,16	NS
Length (L)	4.0	1,27	NS
Parallelism (P)	4.0	1,16	NS
Node Questioned (Q)	7.0	1,16	.05
Sentence Frame (S)	14.6	16,1744	.01
A x S	6.3	16,1744	.01
Subject (C)	6.2	218,1744	.01
S x C	1.2	218,1744	.05
L x K x P	6.6	1,16	.05

[a]Sentence frame, A x S interaction, and subject effect are calculated as F-ratios; other effects are calculated as quasi-F ratios.

TABLE 3

PERCENT CORRECT ON CONTRASTS

Variable	Level	Percent Correct
Paraphrase	Noun	77.4
	Pronoun	68.3
Kernel	Few	73.8
	Many	72.0
Length	Short	75.3
	Long	70.5
Parallelism	Parallel	74.3
	Switched	71.5
Node Questioned	Subject	77.8
	Nonsubject	68.1

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